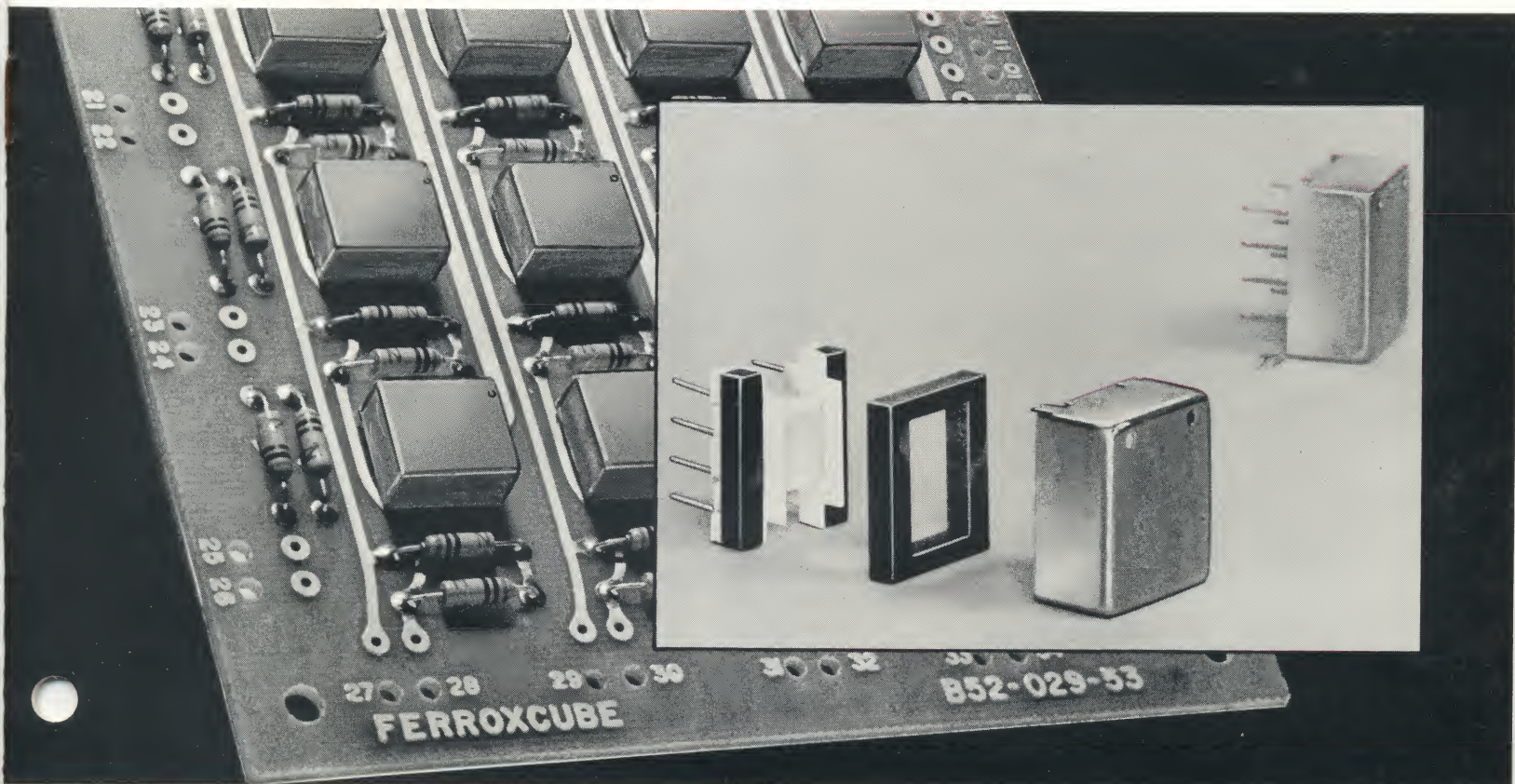


FERROXCUBE ENGINEER



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NO GREATER TESTIMONIAL

to the unique advantages of Ferroxcube Ferrite H-Cores could be asked than the fact that our own memory-system circuit-design team—an incredibly fussy, demanding lot—use them in current-driving circuits for Ferroxcube Memory Systems. The outstanding advantage of the H-Core is, of course, a virtually "gapless" magnetic path, similar to that of a toroid, but without the high winding cost and mounting inconvenience of a toroid.

THE FERROXCUBE ENGINEER

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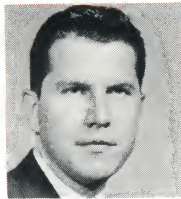
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GIANT MEMORY... GIANT STEP

... an editorial by
John Dymecki

Product Manager, Computer Products

This has seldom happened in the short history of digital data processing. It began with a static register made up of vacuum-tube flip-flops—almost unbelievably bulky, distressingly unreliable, slow as molasses, hot as a pistol... and we've come a long way!

While the new Megabit Memory is not the end of this progression, it *does* mark the climax of a 10-year development program. During that decade, core memories have become faster, smaller, more stable and reliable, and economical enough to take over some functions of drums and discs. Simultaneously, the need developed for higher and higher memory capacity. Drums and Discs have served well; but access to the data they store is difficult and slow, and multiple-search devices are expensive.

We needed something that combined the access speed, reliability, simplicity, and non-volatile storage of a coincident-current memory with the *economy* of drums or discs—with capacity of the order of 5 to 50 million bits.

Here it is: the **Megabit Mass Memory**... a new generation of random-access word-select memories.

John W. Dymecki

FERROXCUBE MEGABIT™ MASS MEMORIES— LESS THAN 2¢ PER BIT.

TRUE RANDOM ACCESS

NARROWS DISC/DRUM PRICE GAP.

—First Independently-Produced Mass Storage System
Ever Offered With this Economy to the Computing/Data-
Processing System Designer and Programmer.

Some years ago, we developed the manufacturing techniques that make possible the construction of magnetic-core storage arrays at extremely low cost per bit of information stored. Now, after refining these processes still further, we are able to offer mass memories in a five-million-bit capacity, with access times of the order of 12 usecs. Megabit 53-12 memories are priced at 1.75¢ per bit, or a price of \$87,500 for a 65 K x 76 system. As a result, a new generation of EDP systems is now possible, and system designers must now take a fresh look at the entire software and peripheral-device picture.

Fundamental to the design of all of the new MEGABITS (family name of the new generation) is the core-plane module shown in Figure 1—a two-wire, 76-bit linear-select core array. Contiguous matrices of millions of bits are easily assembled by forming stacks of these modules, all at remarkably low cost.

As the world's largest manufacturer of memory cores, we are in a position to control cost and quality of the single most expensive and critical element of the entire equipment, and we bring to this job more experience than all others *combined*. (We have strung millions of feet of wire through *billions* of cores!)

The basic building-block of all MEGABIT Memories: 512 switch cores, plus a 256 x 256 memory matrix, linear-select array.

What does the MEGABIT Mass Memory mean to the system designer, the logician, the computer manufacturer? To begin with, it means new design horizons, because the cost, size, and format of a system need not be distorted or over-extended to minimize the storage required. It means new applications, new markets, new *profit* areas—for both large and small computer manufacturers.

Because the 53-12 system is available in a broad range of (readily-extendable) sizes—from capacities as small as 65 K words, 76 bits per word to 512 K words, 76 bits per word—the user is at once able to put into service a memory of a size more appropriate for his immediate requirements, and need never pay for unusable (and costly) overcapacity. This smaller memory can be ordered in the early stages of system design, and 5-million-bit modules can be added later, as final capacity requirements are determined.

The Ferroxcube 53-12 Memory System will find broad application in commercial data processing, in experimental, scientific, private and government laboratories, and in complex digital process-control applications.

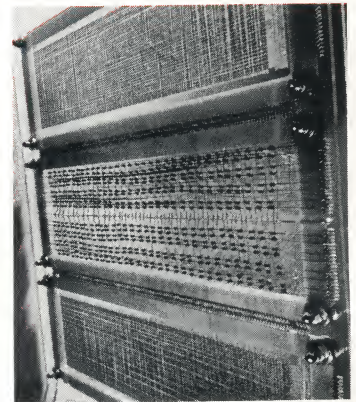


Figure 1.

Designed to make computers function in ways not now possible, this system offers an economical extension of main memory. It also implements new approaches to the design of systems for data retrieval, and for many applications involving the sorting, merging and handling of data.

Existing systems can spend approximately one-third less time in sort-

ing and merging. In addition, Megabit 53-12 memory systems will dramatically increase system capabilities and free up new computation time in current systems.

Figure 2 is a functional block diagram showing the fundamental organization of the megabit memory. The following modes of operation are provided:

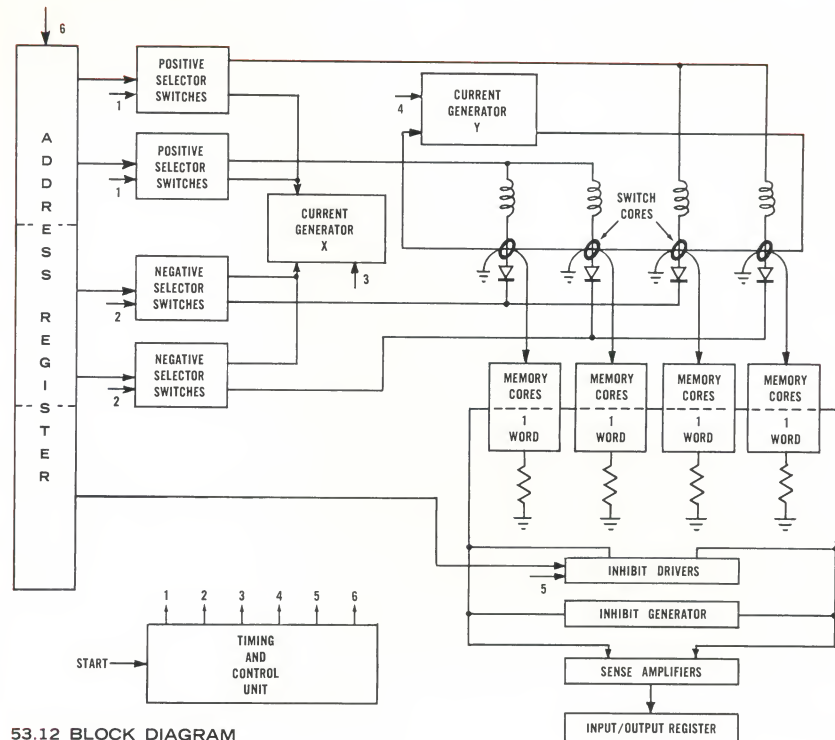
Read-Restore
Clear-Write
Split Cycle (Read/Modify/Write)

The system shown is completely self-contained, and includes power supply, standard memory exerciser and memory retention unit.

In order to minimize the cost of the most expensive part of the megabit memory—the core stack array—it is designed as a *word-address* system, in which the same wire is used for both sense and inhibit. To reduce the number of selection switches, selection is accomplished through the use of a switch core matrix, in which coincident current is used to select the appropriate switch core. Each switch core interrogates the 76 memory cores that go to make up one word. Thus, although the wiring of the switch core matrix is somewhat *more* complicated than that of a conventional coincident current memory matrix, the wiring of the great mass of cores, in the memory proper, is markedly simplified by being reduced to two wires threading each core.

Figure 3 shows the remarkably compact and uncluttered construction of the mass memory, and it illustrates the modular plug-in simplicity of the control circuitry. All the control circuitry, by the way, employs silicon semiconductors and wide-operating margins, for maximum reliability. All control modules are hermetically sealed for maximum environmental stability.

Figure 4 presents a summary of the specifications for the Megabit mass memory line. We invite you to communicate directly with the nearest Ferroxcube Sales Engineering Office, for a full and informative discussion of the new "degrees of freedom", logically, operationally, and competitively, that the 53-12 system offers to the designer and independent manufacturer of digital data processing equipment.



53.12 BLOCK DIAGRAM

Figure 2. Functional Block Diagram of the 53-12 system. Note unique word selection approach, using a switch-core matrix—which eliminates 30% of all semi-conductor requirements, thereby increasing system reliability.



Figure 3. Construction of typical 53-12 mass memory system. Note relatively small sizes (25" x 26" x 70") for the large 65 K capacity (76 bits) provided. All silicon hermetically-sealed, plug-in control modules insure high reliability, minimum "down-time".

Cycle Time.....	12 microseconds.
Access Time	2 microseconds or less.
Capacity	65K x 76 up to 512K x 76, 76 bits per word.
Temperature.....	10°C to 40°C.
Input/Output Levels (Silicon logic).....	Logic "0" = +6 volts. Logic "1" = +0 volts. Can be supplied to meet other equipment requirements.
Power.....	115 Volts, 60 cps.
Physical Dimensions.....	25" wide by 26" deep by 70" high. This is an extremely small unit for a capacity of 65,536 words, 76 bits per word.

Figure 4. Condensed specification summary of new Ferroxcube 53-12 megabit memory systems.

DESIGNING LINEAR TRANSFORMERS

PART I: NARROW-BAND

In the preceding issue, we introduced a set of *explicit* procedures for the design of linear, low-level inductors, using Ferroxcube Ferrite Pot Cores. In this, the next logical step in our Crusade for the Propagation of the Ferrite Faith, we shall describe an equally explicit, equally simple procedure for the design of linear, low-level transformers using standard Ferroxcube Ferrite Cores.

The scope of this endeavor might seem, at first glance, to be far too ambitious for two short articles, particularly when one considers that we must deal with a wide variety of core configurations. Happily, however, our procedure permits us to virtually *ignore* the specific size and shape of the core employed. Once the selection of the core has been made, all of the geometry and core material properties that influence the design are listed as constants in the core-group charts and curves in our forthcoming *BULLETIN 330*, which bears the ambitious title "Applying Ferroxcube Ferrite Cores to the Design of Superior Power Magnetics".

BULLETIN 330 will be available quite soon—perhaps late in March. Knowing the pitch of your consuming passion for the application of Ferroxcube Ferrite Cores to more and more circuit requirements, however, we have extracted and condensed this exposition in advance of the publication of *BULLETIN 330*.

In a *linear transformer*, the excitation of the core is low enough so that the slope of the B vs H curve (see Figure 1) may be considered to be essentially constant. In this region, at or below flux density B_0 , $B_0/H_0 = \mu_e$, a linear relationship exists between the excitation current and the resultant flux, and the permeability of the core is essentially constant at the value μ_e .

In a *low-level transformer*, neither the core losses nor the losses in the windings cause sufficient temperature rise to affect significantly the behavior of the core, or limit the performance of the transformer in any other way. Linear, low-level transformers fall into two broad categories: (1) Narrow-band or low-frequency types, and (2) Broad-band or pulse types. A special case of type (1) is the *tuned* transformer, one or both of the windings of which is resonated at either high or low frequency. Part I of this article will deal only with transformers of type (1). The more difficult designs of Type (2) will be discussed in Part II.

Figure 2 shows a simple two-winding transformer schematically. The primary inductance, L_m , may be calculated from:

$$L_m = 0.4 \pi N_p^2 \mu_e \left[\frac{A_e}{l_e} \right] \times 10^{-8} \text{ (Henries)} \quad (1)$$

For many standard core configurations and core materials, the above calculation has been further simplified by listing a "compound parameter", A_L , the so-called "Inductance Index", which reduces equation (1) to

$$L_m = 10^{-9} N_p^2 A_L \text{ (Henries)} \quad (2)$$

(The dimensions of A_L are "millihenries per thousand turns", incidentally.) If it is desired to calculate the flux density, B , so as to verify operation in the linear region, one may employ the relationship:

$$B = \frac{E_{rms} \times 10^8}{4.44 f N_p A_e} \text{ (gauss)} \quad (3)$$

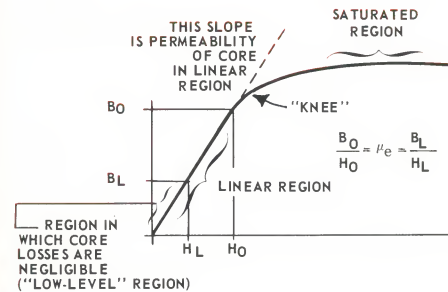


FIGURE 1. MAGNETIZATION CURVE OF A CORE.

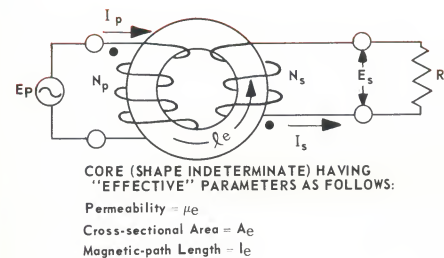


FIGURE 2. ELEMENTARY TRANSFORMER REPRESENTATION.

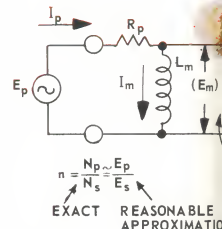


FIGURE 3. SIMPLE, PRACTICAL LOW-FREQUENCY CIRCUIT OF A TRANSFORMER.

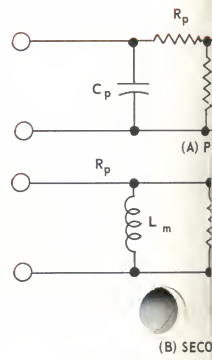


FIGURE 4. RESONANT LOW-FREQUENCY CIRCUIT OF A TRANSFORMER.

where E_{rms} is the voltage impressed across N_p turns, and A_e is the effective core area, given in the charts for each core group in Bulletin 330.

As long as $B \leq B_0$, linear operation is assured. If $B \leq B_L$, then linear, low-level operation is assured.

Figure 3 shows one of the simplest practical *approximate* equivalent circuits one may draw for Figure 2. The term "approximate" must be applied to this circuit because of the following assumptions, upon which its derivation is based:

- Capacitance effects of all kinds are negligible (or may be accounted for as part of the *external* circuitry) for the frequency range of interest.
- Leakage reactance effects for the frequency range of interest are negligible; that is, the coupling between primary and secondary is perfect—all flux established by excitation of either winding links *both* windings, equally and fully.

- Winding resistances are so proportioned that the turns ratio, n , may be considered to be equal to the primary/secondary terminal-voltage ratio; that is:

$$n = \frac{N_p}{N_s} \approx \frac{E_p}{E_s} \quad (4)$$

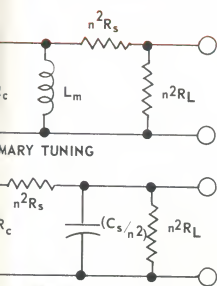
- A simple, "lumped" loss path (R_c) may be considered to represent all core losses.
- All significant winding losses may be represented as series elements (R_p and $n^2 R_s$).

WITH FERROXCUBE FERRITE CORES— ND, LOW-FREQUENCY

LEAKAGE REACTANCE
(ASSUMED NEGLIGIBLE
IN THIS APPROXIMATION).

OFTEN IGNORED IN
"LOW-LEVEL" DESIGNS,
OR USED FOR TUNED-
TRANSFORMER "Q"
CALCULATIONS ONLY.

ICAL (NARROW-BAND,
CY) APPROXIMATE EQUIVALENT
NEAR TRANSFORMER.



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NG THE TRANSFORMER—
QUENCY CASE.

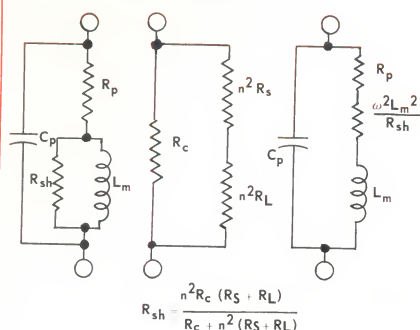


FIGURE 5. Q CALCULATION—PRIMARY RESONANCE.

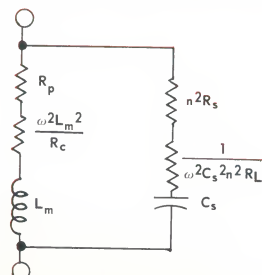


FIGURE 6. Q CALCULATION
—SECONDARY RESONANCE.

In almost all practical designs, the equivalent circuit of Figure 3 may be further simplified in several ways, for the purposes of creating a "first-round" design, after which, the significant effects—if any—of these approximations may be removed by a set of second-round, or "refining" design procedures. In studying the simplifications outlined below, the reader should always bear in mind two precautions: they can be *unwarranted*, in certain special instances; and some of them apply *only* to the simplification of the linear, low-level, narrow-band, low-frequency, equivalent circuit of Figure 3.

- **Calculation of Flux Density and Magnetizing Current.** In practical transformers, the voltage drop across R_p may be neglected in calculating B and I_m , at least for the first-round design. Then $E_m = E_p = E_{rms}$ in equation (3) and equation (6) below.
- **Calculation of Primary Current.** In practical low-level transformers, the core-loss component (I_c) of the primary current may be ignored. Then the primary current consists of only 2 components, in quadrature:

$$I_p = I_s/n + I_m = \sqrt{(I_s/n)^2 + (I_m)^2} \quad (5)$$

$$\text{where } I_m = \frac{E_{rms}}{2\pi f L_m} \quad (6)$$

In many instances, the magnetizing current is so small

that it, too, may be ignored, particularly since it is in quadrature with the load component.

- **Calculation of Required Turns Ratio.** It will be recalled—see equation (4)—that the turns ratio does not exactly relate the terminal voltages, due to the resistances of the primary and secondary winding. The following expression more exactly relates primary and secondary voltages, and permits calculation of an "adjusted" turns ratio that achieves the desired (full load) ratio of primary to secondary voltage. It assumes only that core-loss and I_m may be neglected in the process of correcting the value of n .

$$E_p = E_s \left[n + n \left(\frac{R_s}{R_L} \right) + \frac{1}{n} \left(\frac{R_p}{R_L} \right) \right] \quad (7)$$

This expression becomes far more manageable when one assumes that $R_p = n^2 R_s$; that is, that primary copper loss = secondary copper loss.

Then equation (7) becomes:

$$n = \frac{E_p}{E_s} \left[\frac{R_L}{R_L + 2R_s} \right] \quad (8)$$

In order to design a narrow-band, low-frequency, linear, low-level transformer, the reader need only add two more simple calculations to his design technique: calculation of the required wire size, and checking of the winding "fit".

In low-level transformers, the selection of wire size is not usually governed by current density (heating) but by the need to achieve reasonable voltage regulation—values of R_p and R_s that are low enough to satisfy the requirements of the application. (Note that in many instances a design with quite *high* regulation will perform acceptably.)

For each core configuration, Bulletin 330 furnishes, either directly or indirectly, the exact dimensions and/or area of the available winding space. By apportioning this available space to the bobbin, the primary winding, and the (one or more) secondary windings, together with allowances for insulation, imperfect utilization of the winding space, and wire insulation, the designer is able to assign particular "available primary winding space" (A_p) to the primary windings alone. Then, knowing the number of turns he desires to wind on the primary, as dictated by the necessity to achieve a particular value for L_m , so as to limit the magnetizing current to a reasonable value, he may calculate the cross-sectional area of the *largest* wire that may be used for the primary winding:

$$A_w = \frac{A_p}{N_p} \quad (9)$$

Checking this cross-sectional area against the wire tables, allowing for the particular type of wire insulation selected (assuming that that has not already been accounted for in the estimating of A_p), he can immediately determine the nearest (smaller) wire gauge, and its resistance per unit length.

The primary resistance (R_p) may then be calculated by estimating (from the geometry) the "mean length of turn".

Resonating the Transformer. Figure 4 shows the equivalent circuits for the two configurations in which the linear, low-level transformer may be resonated at low

(continued on page 7)

"...OF MAGNETIC MOMENT"

A Miscellany of
People, Products, and Programs

NEW FIELD SALES MANAGERS BRIEFED AT SAUGERTIES FACILITY



Jack
DeVine



Bill
Walker



Bob
Jones

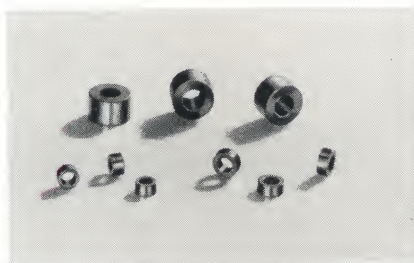
Our three newest regional sales managers—Jack DeVine, Bill Walker, and Bob Jones—spent a good part of last month undergoing a rigorous “sharpening and honing” program here at the Ferroxcube Fountainhead. The program of activities included not only an exhaustive orientation course, in which every product manager and every senior engineer was called upon to lecture and advise the trio, but also a comprehensive tour of duty in each of the fourteen departments involved in the manufacture and quality control of Ferroxcube products. By the time they were “graduated” from this intensive course, Jack, Bill, and Bob were thoroughly familiar with the Ferroxcube product line, and the depth of engineering backup available to our customers. If *you* need truly up-to-date and razor-sharp technical products assistance, it's available to you at your nearest Ferroxcube sales office (see listing, lower right) from men who have been thoroughly trained and *kept current* by regularly scheduled factory refresher courses.

BULLETIN 220 BREAKS ALL PUBLICATION RECORDS

Our Technical Publications Department reports that the requests for Bulletin 220, our brand-new 24-page “Miniature Textbook” on the design of inductive ferrite components, has exceeded all expectations, and wishes us to apologize to any of you

who have not yet received your copy. A second printing was rushed through, and is now in the mails to anyone who requested it.

NEW ULTRA-HIGH PERMEABILITY TOROIDS ANNOUNCED...



Bulletin 301, which is yours for the asking, describes 13 different standard toroids made of a variety of Ferroxcube Ferrites, including the newest—3E2A, with an unequalled initial permeability of 5,000. If you design pulse or wide-band transformers, chokes, and/or small, non-critical inductors, you should have Bulletin 301.



TIME CAPSULE II

IMMORTALITY AT LAST!

FERROXCUBE MEMORY PLANE TO BE INCLUDED IN WESTINGHOUSE TIME CAPSULE II

On October 16, 1965, The Westinghouse Electric Corporation will bury its Time Capsule II at the New York World's Fair. 5,000 years from now, when Capsule II is unearthed, it will reveal a strange and wonderful assortment of 45 articles, representing many facets of the development of our civilization since Time Capsule I was buried in 1938, at the earlier New York World's Fair. We are, of course, proud to have our memory plane selected to represent the electronic computer technology of today, and we take great comfort from this omen of our commercial immortality.

Perhaps less comforting, but stimulating nonetheless, is the company our “memorable matrix” will keep during its 5,000-year siesta; e.g.—a “Bikini” bathing suit, and LP recording by the “Beatles”, tranquilizers, a pocket nuclear radiation monitor... on the other hand, we shall be nestled next to modern antibiotics, a bit of the re-entry heat shield from the Mercury Aurora 7 spacecraft, fuel cells, the modern revised edition of the Holy Bible, and a 50-star U.S. flag. What a life-test *this* is going to be! Our Q.C. department is *green* with envy!

GOING DOWN! MEMORY CORES WILL SOON BE DOWN TO 14 MILS...

...But How About 20 and 30 Mils?

When we announced, at FJCC in San Francisco, and in the last issue of the FERROXCUBE ENGINEER, that we were in prototype production on a 14-mil memory core, we found that some in the industry weren't fully aware of our 20-mil and 30-mil cores, which have been around for over a year, now . . . very distressing; hence this brief review. Is everyone tuned in?

To quote from Bulletin 800A, which you should order today, if you don't have it already: "Ferroxcube is the largest independent producer of

ferrite memory and switch cores in the world. An exclusive formulation and production procedure enables Ferroxcube to produce cores in unequalled uniformity of materials and tolerances."

The smaller the core, the faster the switching, and hence the shorter the read-write cycle time. Thus, a whole new (and faster) generation of memory planes, stacks, and systems are in the offing, using the existing 20-mil and 30-mil cores. We'd be happy to discuss what these cores mean to you.

For your convenience, here's a rapid summary of the current standard Ferroxcube Ferrite Memory Core line. If you don't find what you want here, you're an exception, but ask us—we'll find the answer you want!

Core	Nom. I_f (ma)	Nom. $I/2$ (ma)	@ °C	rV_1 (mv)	dV_z (mv)	T_s (μ s)	Uncompensated Temp. Range	T.C.
20FC01	835	418	40	52	6	0.175	25°C to 65°C	2.3 ma/°C
30FC01	655	328	40	60	8	0.400	25°C to 50°C	3.2 ma/°C
30FC02	670	335	40	42	5	0.480	60°C	1.1 ma/°C
30FC04	470	235	40	54	9	0.410	—	2.5 ma/°C
50FC01	500	250	40	61	6	0.990	—	—
50FC02	1166	583	40	135	20	0.400	—	—
50FC03	367	184	40	60	12	1.200	25°C to 45°C	2.2 ma/°C
50FC04*	450	225	50	65	7	0.900	25°C to 50°C	2.5 ma/°C
50FC05	740	370	40	69	9	1.400	-20°C to +80°C	1.1 ma/°C
80FC01	744	372	40	87	29	1.520	—	—
80FC03	450	225	40	72	24	2.100	—	—

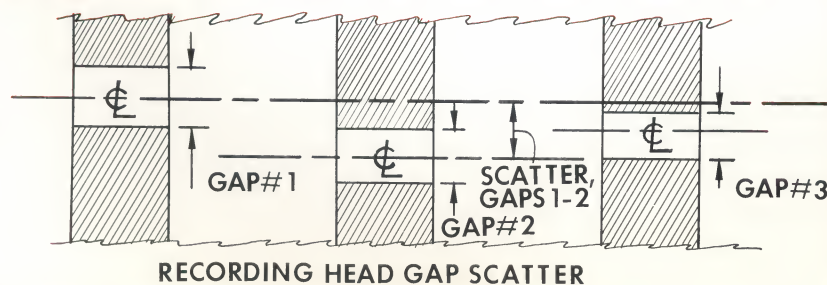
All data average at 40°C unless otherwise noted.
*Measurements made at 50°C.

A NOTE ON RECORDING-HEAD TECHNOLOGY.

In the preceding issue, in the process of describing our remarkable new glass-bonded Flying-Disc and Flying-Drum Recording Heads, we made reference to "gap scatter", a useful parameter by which you may judge the maximum recording density obtainable from a particular recording head. Since then, our correspondence on the subject, which has been gratifyingly lively and vo-

luminous, indicates to us that there exists in the minds of many of our worthiest colleagues in this mystique a confusion concerning the definition of "gap scatter".

The drawing shown here should serve to clarify our definition. In brief, gap scatter may be defined as the variation (or distance) from center-line to center-line in the gaps of a multiple head. A perfect head would have no gap scatter . . . all the gaps would have the same center line. This parameter is, of course, most important in tape applications.



frequencies. It is immediately apparent that the quality factors (Q 's) of the two circuits may be quite different, although the resonant frequency may be made exactly the same, merely by using a secondary capacitor that is n^2 times the primary capacitor.

For primary tuning:

$$Q = \frac{\omega L_m}{R_p + \frac{\omega^2 L_m^2}{R_{sh}}} \text{ and } \omega = \sqrt{\frac{1}{L_m C_p}} \quad (10)$$

For secondary tuning:

$$Q = \frac{\omega L_m}{R_p + \frac{\omega^2 L_m^2}{R_c} + n^2 R_s + \frac{1}{\omega^2 C_s^2 n^2 R_L}} \quad (11)$$

In a tuned transformer, the 3 db-down bandwidth is related to the Q of a resonant circuit by the relationship:

$$BW = 2\Delta f = \frac{1}{Q} \quad (12)$$

(NOTE: The reader will, of course, have observed that leakage reactance is still ignored in these low-frequency examples. When high-frequency or broadband transformers are discussed, in Part II of this article, that restriction will be removed.)

SUMMARY

If the reader will return to Figures 1, 2, and 3, he will find that he has been given all of the necessary theoretical background and design procedures with which to effect a practical design. All he needs is a set of core-group charts and curves—in other words, Bulletin 330 . . . in preparation!

Part II of this article will appear in the next issue.

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Address: Carey-Wolf Co. (Eugene Wolf)
HUNTSVILLE, ALA. (12108 Chickamauga Trail)
Address: Currie Aerospace Associates (Walter Currie)
KANSAS CITY, MO. (4053 Broadway)
Address: Forristal-Young Sales (James Forristal)
NEW YORK, N. Y. (1261 Broadway)
Address: Kahgan Sales Corp. (J. Kahgan)
ORLANDO, FLA. (5119 Louvre Ave.)
Address: Currie Aerospace Associates (Walter Currie)
PHILADELPHIA, PA. (613 W. Cheltenham Ave.)
Address: Eastern Components (A. Spadafora)
PORTLAND, ORE. (2035 S.W. 58 Ave.)
Address: Richard Legg Company (R. Legg)
ROCHESTER, N. Y. (796 Hillside Ave.)
Address: Hart Associates (Lloyd Hart)
ST. LOUIS, MO. (7110 Oakland Ave.)
Address: Forristal-Young Sales (Logan Young)
SAN FRANCISCO, CALIF. (312 Seventh St.)
Address: William J. Purdy Co. (W. Purdy, Jr.)
SEATTLE, WASH. (4013 Leary Way, N.W.)
Address: Richard Legg Company (R. Legg)

CUSTOMERS MEN AT FERROXCUBE

Perhaps the most vital link between our production facilities and you, our customers, is our Customer Service Department . . . or, as we call them, the "customer's men", for they represent *you* on the firing line, where your needs and instructions are transformed into hardware, delivered on schedule. We thought you might like to see your representatives in action, hence this brief photographic essay . . .



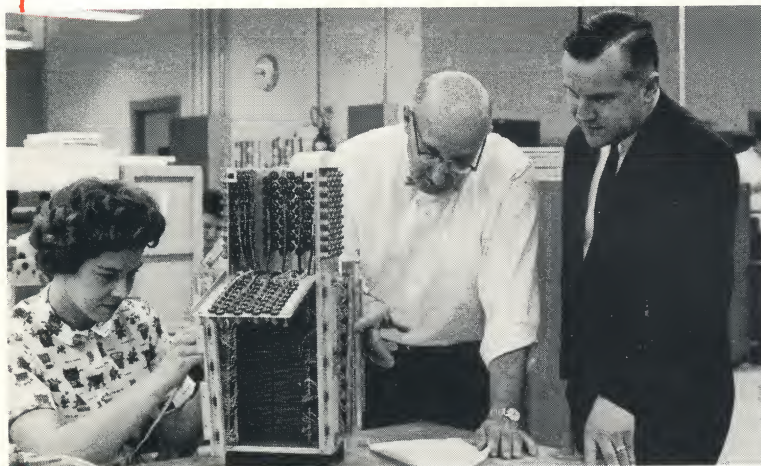
Here Frank Robertello is checking stock on LDR-05's for a personally-expedited rush shipment. Customer's men are free to move everywhere in the plant, doing whatever is necessary and possible to improve delivery schedules.



Howard Noyes, (right) handles all West Coast, Mid-western, and Southwestern States orders. Here he discusses recording-head order progress in engineering area with Wes Robinson (left), Senior Staff Engineer, Recording Heads.



Norman Wheatcroft (left) checks toroid production rate with Al Comito of Production Control. Norm handles orders for all Northeast, Mid-Atlantic, Southeast, and some Southwestern States.



Ed Hellenschmidt, Manager—Customer Service, on the production-assembly floor, checking progress on a large memory stack with Walt Niedzwicki (center), Production Supervisor.



Shipping does not end the process—or the responsibility of the customer's man. Manager Ed Hellenschmidt (left) checks system billing with Mrs. Camilla Tompkins, in the computer room. All final paperwork is processed by computer, for optimum speed and accuracy.



FERROXCUBE CORPORATION OF AMERICA/SAUGERTIES, N.Y.